



FY 1997 Scientific and Technical Reports, Articles, Papers, and Presentations

Compiled by

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Marshall Space Flight Center, Marshall Space Flight Center, Alabama

National Aeronautics and
Space Administration

Marshall Space Flight Center

August 1998

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FOREWORD

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Since July 1, 1960, when the George C. Marshall Space Flight Center was organized, the reporting of scientific and engineering information has been considered a prime responsibility of the Center. Our credo has been that "research and development work is valuable, but only if its results can be communicated and made understandable to others."

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GEORGE C. MARSHALL SPACE FLIGHT CENTER
Marshall Space Flight Center, Alabama

FY 1997 SCIENTIFIC AND TECHNICAL REPORTS
ARTICLES, PAPERS, AND PRESENTATIONS

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NASA TECHNICAL MEMORANDUM

TM-108518

October 1996

Radiation-Induced Degradation of the White Thermal Control Paints Z-93 and Z-93P. D.L. Edwards, J.M. Zwiener, G.E. Wertz, J.A. Vaughn, R.R. Kamenetzky, M.M. Finckenor, and M.J. Meshishnek. Materials and Processes Laboratory.

19970002925N (97N-11712)

This paper details a comparison analysis of the zinc oxide pigmented white thermal control paints Z-93 and Z-93P. Both paints were simultaneously exposed to combined space environmental effects and analyzed using an in-vacuo reflectance technique. The dose applied to the paints was approximately equivalent to 5 years in a geosynchronous orbit. This comparison analysis showed that Z-93P is an acceptable substitute for Z-93.

Irradiated samples of Z-93 and Z-93P were subjected to additional exposures of ultraviolet (UV) radiation and analyzed using the in-vacuo reflectance technique to investigate UV activated reflectance recovery. Both samples showed minimal UV activated reflectance recovery after an additional 190 equivalent Sun hour (ESH) exposure.

Reflectance response utilizing nitrogen as a repressurizing gas instead of air was also investigated. This investigation found the rates of reflectance recovery when repressurized with nitrogen are slower than when repressurized with air.

TM-108519

October 1996

Verification of Orthogrid Finite Element Modeling Techniques. B.E. Steeve. Structures and Dynamics Laboratory. 19970001271N (97N-11105)

The stress analysis of orthogrid structures, specifically with I-beam sections, is regularly performed using finite elements. Various modeling techniques are often used to simplify the modeling process but still adequately capture the actual hardware behavior. The accuracy of such $\bar{\sigma}$ short cuts is sometimes in question. This report compares three modeling techniques to actual test results from a loaded orthogrid panel. The finite element models include a beam, shell, and mixed beam and shell element model. Results show that the shell element model performs the best, but that the simpler beam and beam and shell element models provide reasonable to conservative results for a stress analysis. When deflection and stiffness is critical, it is important to capture the effect of the orthogrid nodes in the model.

TM-108520

October 1996

Acoustic Emission Monitoring of the DC-XA Composite Liquid Hydrogen Tank During Structural Testing. C. Wilkerson. Materials and Processes Laboratory. 19970001260N (97N-11094)

The results of acoustic emission (AE) monitoring of the DC-XA composite liquid hydrogen tank are presented in this report. The tank was subjected to pressurization, tensile, and compressive loads at ambient temperatures and also while full of liquid nitrogen. The tank was also pressurized with liquid hydrogen. AE was used to monitor the tank for signs of structural defects developing during the test.

TM-108521

October 1996

Affordable In-Space Transportation. L.A. Curtis, M.K. Van Dyke, R.M. Lajoie,* and G.R. Woodcock.* Preliminary Design Office. *Missiles and Space Division, Boeing, Huntsville, AL.

19960054362N (96N-36531)

Current and proposed launch systems will provide access to low-Earth orbit (LEO), and destinations beyond LEO, but the cost of delivering payloads will preclude the use of these services by many users. To develop and encourage revolutionary commercial utilization of geosynchronous orbit (GEO) and to provide an affordable means to continue NASA space science and exploration missions, the transportation costs to in-space destinations must be reduced. The principal objective of this study was to conceptually define three to four promising approaches to in-space transportation for delivery of satellites and other payloads, 3,000- to 10,000-lb class, to GEO destinations. This study established a methodology for evaluating in-space transportation systems based on life-cycle cost. The reusable concepts seemed to fare better in the evaluation than expendable, since a major driver in the life-cycle cost was the stage production cost.

TM-108522

October 1996

Project ORION: Orbital Debris Removal Using Ground-Based Sensors and Lasers. J.W. Campbell. Program Development Office.

19960054373N (96N-36541)

About 100,000 pieces of 1- to 10-cm debris in low-Earth orbit are too small to track reliably but large enough

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to cripple or destroy spacecraft. The ORION team studied the feasibility of removing the debris with ground-based laser impulses. Photoablation experiments were surveyed and applied to likely debris materials. Laser intensities needed for debris orbit modification call for pulses on the order of 10kJ or continuous wave lasers on the order of 1 MW. Adaptive optics are necessary to correct for atmospheric turbulence. Wavelength and pulse duration windows were found that limit beam degradation due to nonlinear atmospheric processes. Debris can be detected and located to within about 10 microrads with existing radar and passive optical technology. Fine targeting would be accomplished with laser illumination, which might also be used for detection. Bistatic detection with communications satellites may also be possible. We recommend that existing technology be used to demonstrate the concept at a loss of about \$20 million. We calculate that an installation to clear altitudes up to 800 km of 1- to 10-cm debris over 2 years of operation would cost about \$80 million. Clearing altitudes up to 1,500 km would take about 3 years and cost about \$160 million.

TM-108523, Volume I November 1996
The Microgravity Research Experiments (MICREX) Data Base. C.A. Winter and J.C. Jones.* Space Sciences Laboratory. *University of Alabama in Huntsville. 19970011061N (97N-16110)

An electronic data base identifying over 800 fluids and materials processing experiments performed in a low-gravity environment has been created at NASA Marshall Space Flight Center. The compilation, called MICREX (MICrogravity Research Experiments), was designed to document all such experimental efforts performed (1) on U.S. manned space vehicles, (2) on payloads deployed from U.S. manned space vehicles, and (3) on all domestic and international sounding rockets (excluding those of China and the former U.S.S.R.). Data available on most experiments include (1) principal and co-investigators, (2) low-gravity mission, (3) processing facility, (4) experimental objectives and results, (5) identifying key words, (6) sample materials, (7) applications of the processed materials/research area, (8) experiment descriptive publications, and (9) contacts for more information concerning the experiment. This technical memorandum (1) summarizes the historical interest in reduced-gravity fluid dynamics, (2) describes the experimental facilities employed to examine reduced gravity fluid flow, (3) discusses the importance of a low-gravity fluids and materials processing data base, (4) describes the MICREX data base format and computa-

tional World Wide Web access procedures, and (5) documents (in hard-copy form) the descriptions of the first 600 fluids and materials processing experiments entered into MICREX.

TM-108523, Volume II November 1996
The Microgravity Research Experiments (MICREX) Data Base. C.A. Winter and J.C. Jones.* Space Sciences Laboratory. *University of Alabama in Huntsville. 19970010851N (97N-15970)

An electronic data base identifying over 800 fluids and materials processing experiments performed in a low-gravity environment has been created at NASA Marshall Space Flight Center. The compilation, called MICREX (MICrogravity Research Experiments), was designed to document all such experimental efforts performed (1) on U.S. manned space vehicles, (2) on payloads deployed from U.S. manned space vehicles, and (3) on all domestic and international sounding rockets (excluding those of China and the former U.S.S.R.). Data available on most experiments include (1) principal and co-investigators, (2) low-gravity mission, (3) processing facility, (4) experimental objectives and results, (5) identifying key words, (6) sample materials, (7) applications of the processed materials/research area, (8) experiment descriptive publications, and (9) contacts for more information concerning the experiment. This technical memorandum (1) summarizes the historical interest in reduced-gravity fluid dynamics, (2) describes the experimental facilities employed to examine reduced gravity fluid flow, (3) discusses the importance of a low-gravity fluids and materials processing data base, (4) describes the MICREX data base format and computational World Wide Web access procedures, and (5) documents (in hard-copy form) the descriptions of the first 600 fluids and materials processing experiments entered into MICREX.

TM-108523, Volume III November 1996
The Microgravity Research Experiments (MICREX) Data Base. C.A. Winter and J.C. Jones.* Space Sciences Laboratory. *University of Alabama in Huntsville. 19970026085N (97N-25434)

An electronic data base identifying over 800 fluids and materials processing experiments performed in a low-gravity environment has been created at NASA Marshall Space Flight Center. The compilation, called MICREX (MICrogravity Research Experiments), was

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designed to document all such experimental efforts performed (1) on U.S. manned space vehicles, (2) on payloads deployed from U.S. manned space vehicles, and (3) on all domestic and international sounding rockets (excluding those of China and the former U.S.S.R.). Data available on most experiments include (1) principal and co-investigators, (2) low-gravity mission, (3) processing facility, (4) experimental objectives and results, (5) identifying key words, (6) sample materials, (7) applications of the processed materials/research area, (8) experiment descriptive publications, and (9) contacts for more information concerning the experiment. This technical memorandum (1) summarizes the historical interest in reduced-gravity fluid dynamics, (2) describes the experimental facilities employed to examine reduced gravity fluid flow, (3) discusses the importance of a low-gravity fluids and materials processing data base, (4) describes the MICREX data base format and computational World Wide Web access procedures, and (5) documents (in hard-copy form) the descriptions of the first 600 fluids and materials processing experiments entered into MICREX.

TM-108523, Volume IV November 1996
The Microgravity Research Experiments (MICREX)
Data Base. C.A. Winter and J.C. Jones.* Space Sciences Laboratory. *University of Alabama in Huntsville.
19970026107N(97N-25455)

An electronic data base identifying over 800 fluids and materials processing experiments performed in a low-gravity environment has been created at NASA Marshall Space Flight Center. The compilation, called MICREX (MICrogravity Research Experiments), was designed to document all such experimental efforts performed (1) on U.S. manned space vehicles, (2) on payloads deployed from U.S. manned space vehicles, and (3) on all domestic and international sounding rockets (excluding those of China and the former U.S.S.R.). Data available on most experiments include (1) principal and co-investigators, (2) low-gravity mission, (3) processing facility, (4) experimental objectives and results, (5) identifying key words, (6) sample materials, (7) applications of the processed materials/research area, (8) experiment descriptive publications, and (9) contacts for more information concerning the experiment. This technical memorandum (1) summarizes the historical interest in reduced-gravity fluid dynamics, (2) describes the experimental facilities employed to examine reduced gravity fluid flow, (3) discusses the importance of a low-gravity fluids and materials processing data base, (4)

describes the MICREX data base format and computational World Wide Web access procedures, and (5) documents (in hard-copy form) the descriptions of the first 600 fluids and materials processing experiments entered into MICREX.

TM-108524 November 1996
A New Aging Treatment for Improving Cryogenic Toughness of the Main Structural Alloy of the Super Lightweight Tank. P.S. Chen* and W.P. Stanton. Materials and Processes Laboratory. *IIT Research Institute, Chicago, Illinois.
19970005060N (97N-13045)

Marshall Space Flight Center (MSFC) has developed a new technique that can enhance cryogenic fracture toughness and reduce the statistical spread of toughness values in alloy 2195. This aging treatment can control the location and size of strengthening precipitate T1, making improvements possible in cryogenic fracture toughness (CFT) and fracture toughness ratio (FTR). At the start of this program, design of experiments (DOE) ingot No. 10 was used as a baseline for aging process development and optimization. The new aging treatment was found to be very effective, improving CFT by approximately 15 to 20 percent for DOE ingot No. 10. To further evaluate the repeatability and effectiveness of this new treatment, the investigators selected and tested three more lots of alloy 2195, using 1.75-in-thick gauge plates with FTR values ranging from 0.85 to 1.07. The new aging treatment effectively enhanced CFT and FTR values for all three lots. In one instance, the material was considered rejectable because it did not meet the minimum FTR value (1.0) of the super lightweight tank (SLWT). The new aging treatment improved its FTR from 0.85 to 1.01, making this material acceptable for use in the SLWT.

TM-108525 November 1996
Assessment of Corona/Arcing Hazard for Electron Beam Welding in Space Shuttle Bay at LEO for ISWE: Test Results. A.C. Nunes, Jr., C. Russell, J. Vaughn, C. Stocks, D. O'Dell, and B. Bhat. Materials and Processes Laboratory.
19970005301N (97N-13227)

Test welds were made in argon over a range of pressures from 10-5 to 10-3 torr (the latter pressure an order of magnitude above pressures anticipated in the space shuttle bay during welding) with and without plasma on

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304 stainless steel, 6Al-4V titanium, and 5456 aluminum in search of any possible unwanted electrical discharges. Only a faint steady glow of beam-excited atoms around the electron beam and sometimes extending out into the vacuum chamber was observed. No signs of current spiking or of any potentially dangerous electrical discharge were found.

TM-108526 December 1996
Technology Thresholds for Microgravity: Status and Prospects. D.A. Noever. Space Sciences Laboratory. 19970005379N (97N-13278)

The technological and economic thresholds for microgravity space research are estimated in materials science and biotechnology. In the 1990's, the improvement of materials processing has been identified as a national scientific priority, particularly for stimulating entrepreneurship. The substantial U.S. investment at stake in these critical technologies includes six broad categories: aerospace, transportation, health care, information, energy, and the environment. Microgravity space research addresses key technologies in each area. The viability of selected space-related industries is critically evaluated and a market share philosophy is developed, namely that incremental improvements in a large market's efficiency is a tangible reward from space-based research.

TM-108527 February 1997
Institute Study Report. A. Whitaker, J. Steadman, S. Little, D. Underwood, M. Blackman, and J. Simonds. Space Sciences Laboratory. 19970011667N (97N-16499)

This report documents a study conducted by the MSFC working group on Institutes in 1995 on the structure, organization and business arrangements of Institutes at a time when the agency was considering establishing science institutes. Thirteen institutes, ten science centers associated with the state of Georgia, Stanford Research Institute (SRI), and IIT Research Institute (IITRI), and general data on failed institutes were utilized to form this report. The report covers the working group's findings on institute mission, structure, director, board of directors/advisors, the working environment, research arrangements, intellectual property rights, business management, institute funding, and metrics.

TM-108528, Volume I October 1996
FY 1996 Scientific and Technical Reports, Articles, Papers, and Presentations. Compiled by Joyce E. Turner Waits. Management Operations Office, Human Resources and Administrative Support Office.

This document presents formal NASA technical reports, papers published in technical journals, and presentations by MSFC personnel in FY96. It also includes papers of MSFC contractors.

After being announced in STAR, all of the NASA series reports may be obtained from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

The information in this report may be of value to the scientific and engineering community in determining what information has been published and what is available.

TM-108531 February 1997
Endoscopic Shearography and Thermography Methods for Nondestructive Evaluation of Lined Pressures Vessels. S.S. Russell and M.D. Lansing.* Materials and Processes Laboratory. *University of Alabama in Huntsville. 19970013222N (97N-17150)

The goal of this research effort was the development of methods for shearographic and thermographic inspection of coatings, bonds, or laminates inside rocket fuel or oxidizer tanks, fuel lines, and other closed structures. The endoscopic methods allow imaging and inspection inside cavities that are traditionally inaccessible with shearography or thermography cameras. The techniques are demonstrated and suggestions for practical application are made in this report. Drawings of the experimental setups, detailed procedures, and experimental data are included.

TM-108532 March 1997
Modeling of Rolling Element Bearing Mechanics—Computer Program Updates. S.G. Ryan. Structures and Dynamics Laboratory. 19970015006N (97N-18159)

The Rolling Element Bearing Analysis System (REBANS) extends the capability available with traditional quasi-static bearing analysis programs by including the effects of bearing race and support flexibility. This tool was developed under contract for NASA—

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MSFC. The initial version delivered at the close of the contract contained several errors and exhibited numerous convergence difficulties. The program has been modified in-house at MSFC to correct the errors and greatly improve the convergence. The modifications consist of significant changes in the problem formulation and nonlinear convergence procedures. The original approach utilized sequential convergence for nested loops to achieve final convergence. This approach proved to be seriously deficient in robustness. Convergence was more the exception than the rule. The approach was changed to iterate all variables simultaneously. This approach has the advantage of using knowledge of the effect of each variable on each other variable (via the system Jacobian) when determining the incremental changes. This method has proved to be quite robust in its convergence. This technical memorandum documents the changes required for the original Theoretical Manual and User's Manual due to the new approach.

TM-108533

March 1997

Microgravity Processing and Photonic Applications of Organic and Polymeric Materials (MSFC Center Director's Discretionary Fund Final Report, Project No. 95-26). D.O. Frazier, M.S. Paley,* B.G. Penn, H.A. Abdeldayem,* D.D. Smith, and W.K. Witherow. Space Sciences Laboratory. *Universities Space Research Association. 19970014720N (97N-18034)

Some of the primary purposes of this work are to study important technologies, particularly involving thin films, relevant to organic and polymeric materials for improving applicability to optical circuitry and devices and to assess the contribution of convection on film quality in unit and microgravity environments. Among the most important materials processing techniques of interest in this work are solution-based and by physical vapor transport, both having proven gravitational and acceleration dependence. In particular, polydiacetylenes (PDA's) and phthalocyanines (Pc's) are excellent nonlinear optical (NLO) materials with the promise of significantly improved NLO properties through order and film quality enhancements possible through microgravity processing.

Our approach is to focus research on integrated optical circuits and optoelectronic devices relevant to solution-based and vapor processes of interest in the Space Sciences Laboratory at Marshall Space Flight Center (MSFC). Modification of organic materials is an important aspect of achieving more highly ordered structures

in conjunction with microgravity processing. Parallel activities include characterization of materials for particular NLO properties and determination of appropriate device designs consistent with selected applications.

One result of this work is the determination, theoretically, that buoyancy-driven convection occurs at low pressures in an ideal gas in a thermal gradient from source to sink. Subsequent experiment supports the theory. We have also determined theoretically that buoyancy-driven convection occurs during photodeposition of PDA, an MSFC-patented process for fabricating complex circuits, which is also supported by experiment. Finally, the discovery of intrinsic optical bistability in metal-free Pc films enables the possibility of the development of logic gate technology on the basis of these materials.

TM-108534

April 1997

Rationale and Methods for Archival Sampling and Analysis of Atmospheric Trace Chemical Contaminants On Board *Mir* and Recommendations for the *International Space Station*. J.L. Perry, J.T. James,* H.E. Cole,** T.F. Limero,*** and S.W. Beck.*** Structures and Dynamics Laboratory. *NASA, Lyndon B. Johnson Space Center. **Boeing Defense and Space Group. ***KRUG Life Sciences, Inc.

19970022132N (97N-22738)

Collection and analysis of spacecraft cabin air samples are necessary to assess the cabin air quality with respect to crew health. Both toxicology and engineering disciplines work together to achieve and acceptably clean cabin atmosphere. Toxicology is concerned with limiting the risk to crew health from chemical sources, setting exposure limits, and analyzing air samples to determine how well these limits are met. Engineering provides the means for minimizing the contribution of the various contaminant generating sources by providing active contamination control equipment on board spacecraft and adhering to a rigorous material selection and control program during the design and construction of the spacecraft. A review of the rationale and objectives for sampling spacecraft cabin atmospheres is provided. The presently-available sampling equipment and methods are reviewed along with the analytical chemistry methods employed to determine trace contaminant concentrations. These methods are compared and assessed with respect to actual cabin air quality monitoring needs. Recommendations are presented with respect to the basic sampling program necessary to ensure an acceptably clean spacecraft cabin atmosphere. Also, rationale and recommendations for expanding the scope of the basic monitoring program are discussed.

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TM-108535 May 1997
Inverting the Pendulum Using Fuzzy Control (Center Director's Discretionary Fund Final Report—Project 93-02). R.R. Kissel and W.T. Sutherland. Astrionics Laboratory.
19970021595N (97N-22494)

A single pendulum was simulated in software and then built on a rotary base. A fuzzy controller was used to show its advantages as a nonlinear controller since bringing the pendulum inverted is extremely nonlinear. The controller was implemented in a Motorola 6811 microcontroller. A double pendulum was simulated and fuzzy control was used to hold it in a vertical position. The double pendulum was not built into hardware for lack of time. This project was for training and to show advantages of fuzzy control.

TM-108536 June 1997
NASA's Microgravity Science Research Program. D. Woodard. Microgravity Research Program Office.
19970032027N (97N-29082)

The FY 1996 Annual Report describes key elements of the NASA Microgravity Science Research Program. The program's goals, approach taken to achieve these goals, and available resources are summarized. Highlights and progress in the ground- and flight-based research are provided.

TM-108537 July 1997
Space Tethers: Design Criteria. D.D. Tomlin, G.C. Faile, K.B. Hayashida, C.L. Frost, C.Y. Wagner, M.L. Mitchell, J.A. Vaughn, and M.J. Galuska. Structures and Dynamics Laboratory.
19970027081N (97N-26173)

This document is prepared to provide a systematic process for the selection of tethers for space applications. Criteria are provided for determining the strength requirement for tether missions and for mission success from tether severing due to micrometeoroids and orbital debris particle impacts. Background information of materials for use in space tethers is provided, including electricity-conducting tethers. Dynamic considerations for tether selection is also provided. Safety, quality, and reliability considerations are provided for a tether project.

TM-108538 September 1997
NASA's Microgravity Technology Report—Summary of Activities for 1996. Compiled by Isabella Kierk.
19970041398N (97N-32478)

This document updates the Microgravity Science and Applications Division (MSAD) technology development policy, and presents and assesses current technology-related activities and requirements identified within MSAD research and technology programs. It serves as a prime source of information for the National Research Council, the Administration's Office of Science and Technology Policy, the Office of Management and Budget, and the Congress to promote technology as a means for scientific and economic growth. The report covers technology development and technology transfer activities within the Microgravity Science Research Programs during FY 1996. It also describes the recent major tasks under the Advanced Technology Development (ATD) Program and identifies current technology requirements. This document is consistent with NASA's Enterprise for the Human Exploration and Development of Space (HEDS) Strategic Plan. This annual update reflects changes in the Microgravity Science Research Program's new technology activities and requirements.

TM-108539 August 1997
Random Vibration and Torque Tests of Fasteners Secured With Locking Cable, Room Temperature Vulcanized (RTV) Rubber, and Closed Cell Foam to Support the Launch of STS-82. V.H. Yost. Space Shuttle Main Engine Chief Engineer's Office.
19970034682N (97N-29923)

During a walkdown of the Space Transportation System (STS) orbiter for the 82nd Space Shuttle flight (STS-82), technicians found several safety cables for bolts with missing or loose ferrules. Typically, two or three bolts are secured with a cable which passes through one of the holes in the head of each bolt and a ferrule is crimped on each end of the cable to prevent it from coming out of the holes. The purpose of the cable is to prevent bolts from rotating should they become untightened. Other bolts are secured with either a locking cable or wire which is covered with RTV and foam. The RTV and foam would have to be removed to inspect for missing or loose ferrules. To determine whether this was necessary, vibration and torque test fixtures and tests were made to determine whether or not bolts with missing or loose ferrules would loosen. These tests showed they would not, and the RTV and foam was not removed.

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TM-108540

July 1997

Space Sciences Laboratory Publications and Presentations, January 1–December 31, 1996. Compiled by F.G. Summers. Space Sciences Laboratory.

This document lists the significant publications and presentations of the Space Sciences Laboratory during the period January 1–December 31, 1996. Entries in the main part of the document are categorized according to NASA Reports (arranged by report number), Open Literature, and Presentations (arranged alphabetically by title). Also included for completeness is an Appendix (arranged by page number) listing preprints issued by the Laboratory during this reporting period. Some of the preprints have not been published; those already published are so indicated. Most of the articles listed under Open Literature have appeared in refereed professional journals, books, monographs, or conference proceedings. Although many published abstracts are eventually expanded into full papers for publications in scientific and technical journals, they are often sufficiently comprehensive to include the significant results of the research reported. Therefore, published abstracts are listed separately in a subsection under Open Literature. Questions or requests for additional information about the entries in this report should be directed to Gregory S. Wilson (ES01; 544–7579) or to one of the authors. The organizational code of the cognizant SSL branch or office is given at the end of each entry.

TM-108541

August 1997

International Space Station Program Phase III Integrated Atmosphere Revitalization Subsystem Test Final Report. J.L. Perry, G.D. Franks, and J.C. Knox. Structures and Dynamics Laboratory.
19970034574N (97N-29824)

Testing of the *International Space Station* (ISS) U.S. Segment baseline configuration of the Atmosphere Revitalization Subsystem (ARS) by NASA's Marshall Space Flight Center (MSFC) was conducted as part of the Environmental Control and Life Support System (ECLSS) design and development program. This testing was designed to answer specific questions regarding the control and performance of the baseline ARS subassemblies in the ISS U.S. Segment configuration. These questions resulted from the continued maturation of the ISS ECLSS configuration and design requirement changes since 1992.

The test used pressurized oxygen injection, a mass spectrometric major constituent analyzer, a Four-Bed

Molecular Sieve Carbon Dioxide Removal Assembly, and a Trace Contaminant Control Subassembly to maintain the atmospheric composition in a sealed chamber at ISS specifications for 30 days. Human metabolic processes for a crew of four were simulated according to projected ISS mission time lines. The performance of a static feed water electrolysis Oxygen Generator Assembly was investigated during the test preparation phases; however, technical difficulties prevented its use during the integrated test.

The Integrated ARS Test (IART) program built upon previous closed-door and open-door integrated testing conducted at MSFC between 1987 and 1992. It is the most advanced test of an integrated ARS conducted by NASA to demonstrate its end-to-end control and overall performance. IART test objectives, facility design, pre-test analyses, test and control requirements, and test results are presented.

TM-108542

September 1997

Testing for Random Limit Load Versus Static Limit Load. H.M. Lee. Structures and Dynamics Laboratory.
19970028919N (97N-27636)

This document is an effort to report the basic test findings in an ongoing quest for understanding how random load factors should be applied to structural components in order to verify the strength of space flight hardware. A Spacelab experiment known as the Atmospheric Emission Photometric Imager (AEPI) was subjected to both an expected flight random environment and the associated Miles' equation equivalent static load. During each of these tests, the fiberglass pedestal was instrumented with 16 triaxial strain gauges around its base. Component strains and invariant stresses were compared. As seen previously in other hardware tests, the stress distribution from the random environment was an order of magnitude below the comparable static stresses. With a proposed data acquisition system, a strain database will be developed that will quantify an empirical relationship between dynamic and static limit stresses. This event will allow a more accurate estimate of launch environment effects on new technology structural components.

TM-108543

September 1997

Tether-Based Investigation of the Ionosphere and Lower Thermosphere Concept Definition Study Report. Edited by L. Johnson and M. Herrmann. Program Development Directorate.
19970034863N (97N-30086)

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Understanding the plasma and atmosphere around the Earth in the lower altitude regions of the mesosphere, lower thermosphere, and ionosphere is important in the global electric system. An upper atmosphere tether has been proposed to NASA that would collect much-needed data to further our knowledge of the regions. The mission is proposed as a shuttle experiment that would lower a tethered probe into certain regions of Earth's atmosphere, collecting data over a 6-day period. This report is a summary of the results of a concept definition study to design engineering system that will achieve the scientific objectives of this mission.

TP-3654

October 1996

Prelude to Cycle 23: The Case for a Fast-Rising, Large Amplitude Cycle. R.M. Wilson, D.H. Hathaway, and E.J. Reichmann. Space Sciences Laboratory. 19980002735N

For the common data-available interval of cycles 12 to 22, we show that annual averages of sunspot number for minimum years ($R(\min)$) and maximum years ($R(\max)$) and of the minimum value of the aa geomagnetic index in the vicinity of sunspot minimum ($aa(\min)$) are consistent with the notion that each has embedded within its respective record a long-term, linear, secular increase. Extrapolating each of these fits to cycle 23, we infer that it will have $R(\min)=12.7\pm5.7$, $R(\max)=176.7\pm61.8$ and $aa(\min)=21.0\pm5.0$ (at the 95-percent level of confidence), suggesting that cycle 23 will have $R(\min)\geq 7.0$, $R(\max)\geq 114.9$, and $aa(\min)\geq 16.0$ (at the 97.5-percent level of confidence). Such values imply that cycle 23 will be larger than average in size and, consequently (by the Waldmeier effect), will be a fast riser. We also infer from the $R(\max)$ and $aa(\min)$ records the existence of an even-odd cycle effect, one in which the odd-following cycle is numerically larger in value than the even-leading cycle. For cycle 23, the even-odd cycle effect suggests that $R(\max) > 157.6$ and $aa(\min) > 19.0$, values that were recorded for cycle 22, the even-leading cycle of the current even-odd cycle pair (cycles 22 and 23). For 1995, the annual average of the aa index measured about 22, while for sunspot number, it was about 18. Because $aa(\min)$ usually lags $R(\min)$ by 1 year (true for 8 of 11 cycles) and 1996 seems destined to be the year of $R(\min)$ for cycle 23, it may be that $aa(\min)$ will occur in 1997, although it could occur in 1996 in conjunction with $R(\min)$ (true for 3 of 11 cycles). Because of this ambiguity in determining $aa(\min)$, no formal prediction based on the correlation of $R(\max)$ against $aa(\min)$, having $r = 0.90$, or of $R(\max)$ against the combined effects of $R(\min)$ and $aa(\min)$ —the bivariate technique—having $r = 0.99$ is possible until 1997, at the earliest.

TP-3663

November 1996

Low-Temperature Mechanical Testing of Carbon-Fiber/Epoxy-Resin Composite Materials. A.T. Nettles and E.J. Biss. Materials and Processes Laboratory. 19970003683N (97N-12371)

The use of cryogenic fuels (liquid oxygen and liquid hydrogen) in current space transportation vehicles, in combination with the proposed use of composite ma-

terials in such applications, requires an understanding of how such materials behave at cryogenic temperatures. In this investigation, tensile intralaminar shear tests were performed at room, dry ice, and liquid nitrogen temperatures to evaluate the effect of temperature on the mechanical response of the IM7/8551-7 carbon-fiber/epoxy-resin system.

Quasi-isotropic lay-ups were also tested to represent a more realistic lay-up. It was found that the matrix became both increasingly resistant to microcracking and stiffer with decreasing temperature. A marginal increase in matrix shear strength with decreasing temperature was also observed. Temperature did not appear to affect the integrity of the fiber-matrix bond.

TP-3667

January 1997

Solution of the Angles-Only Satellite Tracking Problem. R.E. Burns. Structures and Dynamics Laboratory. 19970012913N (97N-17038)

A single observation station, located at an arbitrary point on the surface of the Earth, can determine only the azimuth and elevation angles of a satellite or ballistic vehicle, and the time at which these observations occur. No information is available about the range or the range-rate of the target. It is shown that five observations of either the elevation or the azimuth, and the time of either set of observations, determine the complete set of orbital elements of the target. The implementation of the theory presented here could provide a great reduction in the hardware costs associated with satellite and reentry vehicle tracking.

TP-3674

February 1997

Gauging the Nearness and Size of Cycle Minimum. R.M. Wilson, D.H. Hathaway, and E.J. Reichmann. Space Sciences Laboratory. 19970014934N (97N-18137)

By definition, the conventional onset for the start of a sunspot cycle is the time when smoothed sunspot number (i.e., the 12-month moving average) has decreased to its minimum value (called minimum amplitude) prior to the rise to its maximum value (called maximum amplitude) for the given sunspot cycle. On the basis of the modern era sunspot cycles 10-22 and on the presumption that cycle 22 is a short-period cycle having a cycle length of 120 to 126 months (the observed range of short-period modern era cycles), conventional onset for cycle 23 should not occur until sometime between September

1996 and March 1997, certainly between June 1996 and June 1997, based on the 95-percent confidence level deduced from the mean and standard deviation of period for the sample of six short-period modern era cycles.

Also, because the first occurrence of a new cycle, high-latitude (≥ 25 degrees) spot has always preceded conventional onset of the new cycle by at least 3 months (for the data-available interval of cycles 12–22), conventional onset for cycle 23 is not expected until about August 1996 or later, based on the first occurrence of a new cycle 23, high-latitude spot during the decline of old cycle 22 in May 1996. Although much excitement for an earlier-occurring minimum (about March 1996) for cycle 23 was voiced earlier this year, the present study shows that this exuberance is unfounded. The decline of cycle 22 continues to favor cycle 23 minimum sometime during the latter portion of 1996 to the early portion of 1997.

TP-3677 March 1997
United States Control Module Guidance, Navigation, and Control Subsystem Design Concept. M.E. Polites and B.E. Bartlow. Astrionics Laboratory.
19970017408N (97N-19685)

Should the Russian Space Agency (RSA) not participate in the *International Space Station (ISS)* program, then the United States (U.S.) National Aeronautics and Space Administration (NASA) may choose to execute the *ISS* mission. However, in order to do this, NASA must build two new space vehicles, which must perform the functions that the Russian vehicles and hardware were to perform. These functions include periodic *ISS* orbit reboost, initial *ISS* attitude control, and U.S. On-Orbit Segment (USOS) control moment gyroscope (CMG) momentum desaturation. The two new NASA vehicles that must perform these functions are called the U.S. control module (USCM) and the U.S. resupply module.

This paper presents a design concept for the USCM GN&C subsystem, which must play a major role in *ISS* orbit reboost and initial attitude control, plus USOS CMG momentum desaturation. The proposed concept is structured similar to the USOS GN&C subsystem, by design. It is very robust, in that it allows the USCM to assume a variety of vehicle attitudes and stay power-positive. It has a storage/safe mode that places the USCM in a gravity-gradient orientation and keeps it there for extended periods of time without consuming a great deal of propellant. Simulation results are presented and discussed that show the soundness of the design approach. An equipment list is included that gives detailed information on the baselined GN&C components.

TP-3698 September 1997
Corrosion Studies of Wrought and Cast NASA-23 Alloy. M.D. Danford. Materials and Processes Laboratory.
19970034987N (97N-30203)

Corrosion studies were carried out for wrought and cast NASA-23 alloy using electrochemical methods. The scanning reference electrode technique (SRET), the polarization resistance technique (PR), and the electrochemical impedance spectroscopy (EIS) were employed. These studies corroborate the findings of stress corrosion studies performed earlier, in that the material is highly resistance to corrosion.

TP-3704 August 1997
Design of Launch Vehicle Flight Control Augmentors and Resulting Flight Stability and Control (Center Director's Discretionary Fund Project 93-05, Part III). C. Barret, Ph.D. Propulsion Laboratory.
19970037712N (97N-31151)

This report is Part III, the final part, of the Center Director's Discretionary Fund (CDDF) Project 93-05, in which the author as Principal Investigator has proposed and designed forward and aft, all-movable, blunt trailing-edge (TE), flight control augmentors (FCA's) to provide the required control augmentation for a family of aft center-of-gravity (cg) launch vehicles that could not be adequately controlled using engine gimbaling alone. This comprehensive flight mechanics research effort has been partially documented in previous publications. NASA TP-3535 (Barret, C.; February 1995) has presented the state-of-the art assessment of smart materials and advanced composites directly applicable to the innovative design of the FCA's. NASA TP-3615 (Barret, C.; April 1996) has presented the developmental stages of the program, the comprehensive reviews of our national heritage of launch vehicles that have used aerodynamic surfaces, and the current use of these by other nations.

This publication presents the control requirements, the details of the designed FCA's, the static stability and dynamic stability wind tunnel test programs, the static stability and control analyses, the dynamic stability characteristics of the experimental LV with the designed FCA's, and a consideration of the elastic vehicle. Dramatic improvements in flight stability have been realized with all the FCA designs; these ranged from 41 percent to 72 percent achieved by the blunt TE design. The control analysis showed that control increased 110 percent with only 3 degrees of FCA deflection. The dynamic

stability results showed improvements with all FCA designs tested at all Mach numbers tested. The blunt TE FCA's had the best overall dynamic stability results. Since the lowest elastic vehicle frequency must be well separated from that of the control system, the significant frequencies and modes of vibration have been identified, and the response spectra compared for the experimental LV in both the conventional and the aft cg configuration. Although the dynamic response was 150 percent greater the aft cg configuration, the lowest bending mode frequency decreased by only 2.8 percent.

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| KINTNER, P.M. | Cornell University | | |
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| ROMERO, M. | New Mexico Highlands | The NASA Integrated Information Technology Ar- | |
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| GREINER, J. | Max-Planck-Institut, Germany | NOEVER, D.A. | ES76 |
| KOUVELIOTOU, C. | USRA | Excursion Set Mediated Evolutionary Strategy. For | |
| VAN PARADIJS, J. | UAH | presentation at International Conference on Artifi- | |
| LIDMAN, C. | ESO | cial Neural Networks and Genetic Algorithms, Nor- | |
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| MCCALL, S.D. | Alabama A&M University | |
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| CHRISTIAN, H. | ES41 | |
| BOECK, W.L. | Niagara University | |
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| REPORT DOCUMENTATION PAGE | | | Form Approved OMB No. 0704-0188 | |
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| Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operation and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503 | | | | |
| 1. AGENCY USE ONLY (Leave Blank) | | 2. REPORT DATE August 1998 | 3. REPORT TYPE AND DATES COVERED Technical Memorandum | |
| 4. TITLE AND SUBTITLE FY 1997 Scientific and Technical Reports, Articles, Papers, and Presentations | | | 5. FUNDING NUMBERS | |
| 6. AUTHORS J.E. Turner Waits, Compiler | | | | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama 35812 | | | 8. PERFORMING ORGANIZATION REPORT NUMBER M-895 | |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) National Aeronautics and Space Administration Washington, DC 20546 | | | 10. SPONSORING/MONITORING AGENCY REPORT NUMBER NASA/TM—1998-208801 | |
| 11. SUPPLEMENTARY NOTES Prepared by Technical Information & Operations Services Office, Center Operations Directorate | | | | |
| 12a. DISTRIBUTION/AVAILABILITY STATEMENT Unclassified-Unlimited Availability: NASA CASI (301) 621-0390 Nonstandard Distribution | | | 12b. DISTRIBUTION CODE | |
| 13. ABSTRACT (Maximum 200 words) This document presents formal NASA technical reports, papers published in technical journals, and presentations by MSFC personnel in FY97. It also includes papers of MSFC contractors. After being announced in STAR, all of the NASA series reports may be obtained from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. The information in this report may be of value to the scientific and engineering community in determining what information has been published and what is available. | | | | |
| 14. SUBJECT TERMS | | | 15. NUMBER OF PAGES 72 | |
| | | | 16. PRICE CODE A05 | |
| 17. SECURITY CLASSIFICATION OF REPORT Unclassified | 18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified | 19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified | 20. LIMITATION OF ABSTRACT Unlimited | |